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(71) Applicant: **Danmarks Tekniske Universitet
2800 Kgs. Lyngby (DK)**

(72) Inventors:
• **Pedersen, Henrik Chresten
4040 Jyllinge (DK)**

• **Brockmann, Thomas
2100 Copenhagen Ø (DK)**
• **Dam-Hansen, Carsten
2630 Taastrup (DK)**

(74) Representative: **Schwarze, Holm
Guardian IP Consulting I/S
Diplomvej, Building 381
2800 Kgs. Lyngby (DK)**

(54) **Light engine for an illumination device**

(57) Disclosed herein are embodiments of a light engine for an illumination device, the light engine defining an output gate and being configured to output light from said output gate; wherein the light engine comprises: one or more light sources defining a light-emitting area; a concave reflector configured to receive light from the light-emitting area and to direct light from respective portions of the light-emitting area to form a converging beam that converges towards a beam spot at the output gate.

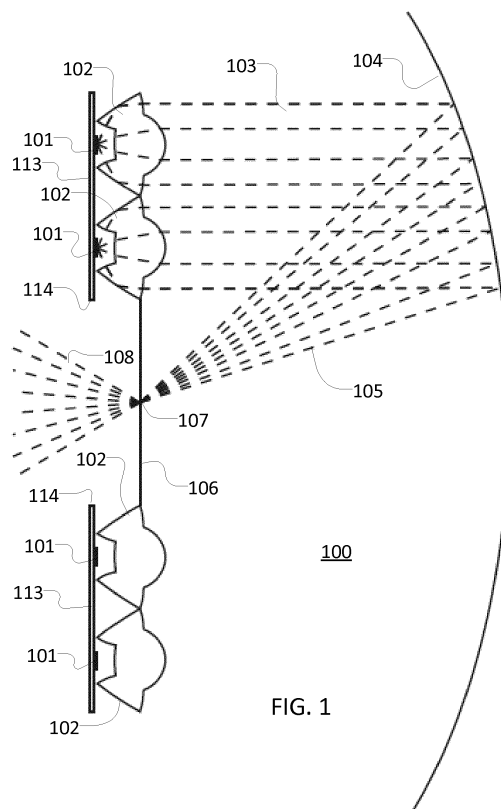


FIG. 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to a light engine for an illumination device, in particular an illumination device for stage lighting, studio lighting of TV studios or other studios, architectural lighting, museum lighting, internal lighting, external illumination of buildings, monuments or the like, head lamps for automobiles, bicycles or the like.

BACKGROUND

[0002] Illumination devices such as spotlights are widely used for stage lighting, studio lighting etc. It is generally desirable that such illumination devices are energy efficient, i.e. they have a high efficiency. Moreover, it is generally desirable that the area to be illuminated may be delimited by masking elements, often also referred to as "barn doors," such that the effective illuminated area has well-defined boundaries between illuminated and dark areas, i.e. without or with only very limited transitional areas of decreasing illumination along the edge of the illuminated area.

[0003] For head lamp applications it is generally desirable that a certain light intensity distribution is achieved on the road.

[0004] In some applications it may be desirable to illuminate an object or an area by a spot light from a relatively large distance, e.g. because it is not feasible or desirable to provide an illumination device close to the object or area to be illuminated. In such applications it is desirable to provide a focused or collimated light beam with as little divergence as possible.

[0005] Conventional illumination devices based on halogen lamps or other types of lamps are known. However, these have a relatively low light efficiency, i.e. a large fraction, often up to 90%, of the electrical effect used to operate such lamps is transferred into radiated heat.

[0006] More recently, illumination devices have been suggested that comprise a light engine which combines light from a number of light-emitting diodes (LEDs). WO2012/167799 discloses an LED-based illumination system where light from multiple LEDs is directed by a lens system to a target area.

[0007] Even though such prior art LED-based illumination devices have an improved light efficiency, they provide illuminated areas having less well-defined edges, as the individual LED's are not point-like sources but rather emit light from light-emitting surfaces.

SUMMARY

[0008] According to a first aspect, disclosed herein are embodiments of a light engine for an illumination device, the light engine defining an output gate and being configured to output light from said output gate; wherein the

light engine comprises:

- one or more light sources defining a light-emitting area;
- a concave reflector configured to receive light from the light-emitting area and to direct light from respective portions of the light-emitting area to form a converging beam that converges towards a beam spot at the output gate.

[0009] Generally, an embodiment of the light engine described herein functions as a localized virtual light source that emits light from a small beam spot which defines the virtual light source. To this end the light engine combines light from one or more individual light sources that together define a light-emitting area. The concave reflector of the light engine directs a combined, converging beam to the beam spot where light from different portions of the light-emitting area is concentrated into the localized beam spot.

[0010] The inventors have realized that a concave reflector allows for an improved focusing of the light from different parts of an extended light-emitting area to a small beam spot. Moreover, it has turned out that, when each light source emits light from a light-emitting surface rather than a point-like source, a concave reflector provides a more efficient focusing of the light from each light source into a smaller beam spot than a transmissive element like a lens or Fresnel lens. It will be appreciated that the converging beam is generally not focused into an ideal focal point, in particular not when the individual light sources deviate from point sources and emit light from light emitting surfaces having certain finite areas. However, embodiments of the light engine described herein allow the spot size of the beam spot into which the converging beam is focused to be kept small. Hence, for the purpose of the present disclosure, the term beam spot is intended to refer to a beam cross section, e.g. at a beam waist of the converging beam. The size of the beam spot may e.g. be defined as the size of the beam cross section at the beam waist including a predetermined fraction of the total beam energy. The spot size may be expressed as an area or a diameter of the beam spot.

[0011] Consequently, the light engine may be arranged to operate as a virtual localized light source that may at least approximately be considered as a virtual point like light source that emits light from a localized output gate.

[0012] Embodiments of the light engine thus provide light that can illuminate a target area having well-defined boundaries while allowing the use of light sources having a high light efficiency. Furthermore, embodiments of the light engine provide light that can be collimated (or at least quasi-collimated) to form a collimated or quasi-collimated beam having a low divergence, so as to allow well-defined illumination of areas or objects from large distances. Moreover, embodiments of the light engine

described herein are suitable for use in illumination devices that are to be configured to provide a well-defined light intensity distribution.

[0013] The output gate may be defined by an aperture, a diffuser plate, a microlens array and/or other optical element. Alternatively, the output gate may merely be defined by a beam waist of the reflected beam from the concave reflector. The output gate may be defined by a focal plane of the reflector. The concave reflector may be configured to direct the converging beam to converge in a beam spot in a plane defined by an optical element such as an aperture, a diffuser plate or a microlens.

[0014] In some embodiments the light-emitting area is an annular area defining a central aperture; and the concave reflector is arranged to combine the light from the light sources to direct the converging beam through the aperture. This arrangement provides a particularly uniform and well-defined output beam and a particular efficient and uniform utilization of light from the entire light-emitting area.

[0015] Generally, the concave reflector is reflective at least in respect of light of a predetermined wavelength range. It will be appreciated that the concave reflector may be reflective in respect of a first wavelength range while being transmissive or otherwise non-reflective in respect of light of a second wavelength range.

[0016] In some embodiments the concave reflector comprises an annular portion and a central portion surrounded by the annular portion. The annular portion is formed by, or comprises, a reflective surface of the concave reflector, which reflective surface is reflective at least in respect of light of a predetermined wavelength range, in particular a wavelength range comprised in the light emitted by the annular light emitting area, preferably a wavelength range covering a major part of the light emitted by the annular-light emitting surface. The central portion may be a central opening defined by an inner rim of the annular portion. Alternatively, the central portion may be a non-reflective, partially reflective and partially transmissive, or a transmissive portion. The light from the light sources, e.g. from the annular light-emitting area, is directed by one or more optical elements to, preferably only or at least predominantly, the annular, reflective portion of the reflector.

[0017] The light engine may further comprise one or more additional light sources operable to direct light towards the central aperture defined by the annular light-emitting area, thereby increasing the total light emitting area of the light engine. The additional light sources thus face the central aperture and emit light in a direction generally opposite of the light emitted by the annular light-emitting area, i.e. away from the reflective surface of the reflector. The light from the additional light sources may be directed by one or more additional optical elements as a converging beam towards the output gate. The additional optical element(s) may comprise a collimating and a focussing lens or merely a focussing lens. The lenses may be implemented as separate components or

combined to a single lens structure. For example, the lens may be formed by a TIR lens having a collimating light-receiving face facing at least one of the one or more additional light sources and a focussing, light-emitting surface facing the central aperture defined by the annular light-emitting area. The light-emitting surface of the lens may e.g. be formed as a Fresnel lens. The additional light source(s) and, optionally, the additional optical element(s) may be mounted behind (with respect to the aperture) a partially transmissive portion of the concave reflector, e.g. an annular portion of the reflector. Alternatively, the additional light sources may be arranged aligned with the central portion of the reflector (e.g. radially within the area of the central portion), and the additional light source(s) and the additional optical element(s) may be positioned behind or in front of the central portion of the reflector which central portion may thus be left non-reflective. Yet alternatively, the additional light source(s) or the additional optical element(s) may be mounted flush with a central opening of the reflector.

[0018] In some embodiments, the annular portion of the reflector may be partially reflective and partially transmissive. In particular, the annular portion may be transmissive in a first spectral range and reflective in a second, different spectral range. In some embodiments the annular portion is transmissive at wavelengths above a threshold wavelength and reflective at wavelengths below the threshold wavelength. For example, the annular portion may be formed as a colour interference filter, e.g. a dichroic filter. Accordingly the light sources of the annular light-emitting area may be operable to at least predominantly emit light within the second spectral range, e.g. predominantly below the threshold wavelength of the central portion (e.g. predominantly blue and green light) and the additional light sources may be mounted behind (seen from the annular light emitting area) the annular portion of the reflector and operable to at least predominantly emit light in the first spectral range e.g. predominantly above the threshold wavelength (e.g. predominantly red light). The light from the additional light sources may thus be directed from the additional light sources through the partially transmissive reflector towards the output gate.

[0019] In some embodiments, the light engine comprises at least one optical element configured to direct light from at least one of the one or more light sources towards the reflector and wherein the reflector is arranged to reflect the light as a converging beam towards said beam spot at said output gate. The optical element may be a collimator that at least partially collimates the light or even provide a converging light beam.

[0020] In particular, in some embodiments, the light engine comprises at least one collimator configured to direct light from at least one of the one or more light sources as collimated light towards the reflector and wherein the reflector is arranged to reflect the collimated light as a converging beam towards said beam spot at said output gate. When the light from the light source(s) is directed

towards the reflector as collimated light, the reflected light may accurately be converged in a small beam spot. For example, the light engine may comprise a plurality of light sources and a plurality of collimators each adapted to receive light from one of the light sources and to direct a collimated (or quasi-collimated) beam towards the reflector. In some embodiments the collimator is a Total Internal Reflection (TIR) lens, comprising a light-receiving input surface, a light-emitting output surface and a lateral surface; the input surface has a central portion and an annular portion; the central portion is configured to at least partially collimate received light and to direct the received light towards the output surface, and the annular portion is operable to direct received light towards the lateral surface for total internal reflection of the light towards the output surface.

[0021] While in some embodiments, the output surfaces of the collimators may be planar, other embodiments of the light engine may comprise collimators having a light-emitting output surface with a central portion and an annular portion that surrounds the central portion; the central and annular portions may have respective radius of curvatures, e.g. the central portion may have a smaller radius of curvature than the annular portion. Here and in the following, the term curvature of a surface refers to the curvature of a cross-section of the surface and may be quantified by a radius of curvature. Consequently, the shaping of the beam towards the reflector may be performed both by the light-receiving input surface of the collimator and by the light-emitting output surface. It has been found that utilizing both surfaces of the collimators increases the beam quality of the collimated beam and allows a better convergence of the reflected beam into a small beam spot. It will be appreciated that, in some embodiments, one of the central and the annular portions of the input or output surface may have a very large or even infinite radius of curvature, i.e. be planar, while the other portion of said input or output surface has a convex or concave shape.

[0022] When the concave reflector is a parabolic reflector, a particularly accurate convergence of the reflected light beam into a small beam spot is provided. Generally, when the light engine is operable to generate a small beam spot into which a major portion of the light from the light sources is converged, the light engine operates as a localized or even point-like virtual light source. Consequently, the light generated by the light engine may be accurately shaped by one or more suitable optical elements to form a collimated beam of low convergence/divergence and/or to illuminate an area such that the boundaries between the illuminated area and the surrounding of the illuminated area may accurately be defined with no or only minimal transitional boundary zones.

[0023] The skilled person will appreciate that the advantages provided by the present light engine can be applied to numerous types of light sources. In some embodiments, the light engine comprises a plurality of light sources distributed across the light-emitting area, thus

allowing a high light efficiency while still functioning as a localized virtual light source. In some embodiments, each light source and, optionally, each additional light source, comprises one or more Light-emitting Diodes (LEDs), thus providing a particularly energy-efficient illumination while allowing an accurate delimiting of the illuminated area. LEDs are typically small light sources thus allowing an accurate shaping and directing of the resulting emitted light. Alternatively or additionally, embodiments of a light engine may comprise one or more other light sources and/or, optionally, additional light source(s), such as lasers, VCSELs, quantum dots, etc.

[0024] In some embodiments, the light engine comprises light sources emitting light having different respective spectral distributions, e.g. light of different chromaticity. For example, the light engine may comprise red, green and blue light sources e.g. LEDs. The concave reflector thus combines light of different color to a mixed converging beam. When the light engine comprises or is connectable to a control circuit that is configured to selectively control respective ones of the light sources, or respective subsets of the light sources, the light engine may be operated as a light mixer operable to output light of different chromaticity. Similarly the light engine may mix light from a plurality of light sources so as to control one or more other parameters of the mixed output light.

[0025] The present invention relates to different aspects including the light engine described above and in the following, a corresponding illumination device and other apparatus, systems, methods, and/or products, each yielding one or more of the benefits and advantages described in connection with the first mentioned aspects, and each having one or more embodiments corresponding to the embodiments described in connection with the first mentioned aspects and/or disclosed in the appended claims.

[0026] In particular, according to one aspect, disclosed herein are embodiments of an illumination device for illuminating a target area, the illumination device comprising a light engine as described herein and one or more optical device configured to receive light from the output gate of the light engine and to direct the received light towards the target area.

[0027] The optical device may include one or more reflective elements and/or one or more transmissive elements. For example, the optical device may include an optical lens or lens system and/or one or more reflectors. In some embodiments, the optical device comprises a collimating or a focusing lens.

[0028] According to some embodiments, the illumination device further comprises shaping elements, such as masking elements, for selectively delimiting the illuminated area. The shaping elements may be movably arranged so as to block a portion of the light from the illumination device and to adjust the shape of the illuminated area.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] Embodiments of the invention will be described in more detail in connection with the appended drawings, in which:

FIG. 1 illustrates an example of a light engine.

FIG. 2 shows a front view of the light-emitting area of the light engine of FIG. 1.

FIGS. 3 and 4 show more detailed views of examples of a light source with a collimating lens.

FIG. 5 shows an example of an illumination device.

FIGs. 6-9 illustrate examples of a light engine comprising additional light sources.

[0030] Throughout the drawings, like reference numerals refer to like or corresponding features, elements or components.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0031] FIG. 1 illustrates a cross-sectional view of an example of a light engine, generally designated 100. The light engine comprises a plurality of light sources 101, a plurality of collimators 102, a concave reflector 104 and a diffuser plate 106. Generally the reflector faces the light sources, and the light sources are configured to direct light towards the reflector and into the open end of the reflector.

[0032] In the example of FIG. 1, the light sources are light-emitting diodes (LEDs) each having a light-emitting surface facing the reflector 104. It will be appreciated that other embodiments may use other types of light sources. The light sources are annularly arranged on a support plate 113 around a central aperture defined by the inner edge 114 of the support plate 113. The support plate may e.g. be a printed circuit board on which the LEDs are mounted. The central aperture is covered by the diffuser plate 106. Hence, the light sources together define an annular light emitting surface that directs light towards the reflector.

[0033] Each of the collimators 102 is positioned in front of one of the light sources 101 and configured to receive light from the respective light source and to direct a collimated beam 103 towards the concave reflector 104. In the example of FIG. 1, the collimators 102 are total internal reflection lenses, but other types of collimating optical elements may be used instead.

[0034] FIG. 2 illustrates a top view of the support plate 113 with the light sources 191 and collimators 102 arranged around the central aperture. In some embodiments, a light engine may comprise tens or even more than hundred LEDs. It will be appreciated that other embodiments may comprise a different number and/or a different arrangement of light sources. For example, even though the collimators 102 are shown as separate elements, it will be appreciated that some or all of the colli-

matoms may be combined into a single component, e.g. a moulded plastic component.

[0035] The concave reflector 104 may e.g. be a metal-coated plastic or glass reflector, a dielectric mirror, or another form of reflector. The concave reflector 104 is a parabolic reflector configured to receive the respective collimated beams 103 from the collimators 102 and to converge all received light beams into a converging beam 105 which converges onto a beam spot 107 on the diffuser plate 106. Hence the light 108 output by the light engine through the diffuser plate 106 appears to originate from a virtual point-like source at the beam spot 107. Even though it will be appreciated that the beam spot has a certain finite size rather than being an ideal point-source, embodiments of the light engine described herein provide a very small, well-localised beam spot 107, even if the light sources 101 emit light over a relatively large area, e.g. an area of the order of 1 mm². The parabolic shape of the reflector is believed to be particularly well-suited for producing a small beam spot. Simulations performed by the inventors indicate that the embodiment a light engine shown in FIG. 1 provides a light efficiency that is more than 40% higher than a corresponding light engine, where the parabolic reflector is replaced by a lens and the light is output in a forward direction (as defined by the direction of light emission of the light sources) rather than a backward configuration as in FIG. 1, where the light exits the output gate in a direction opposite to the direction of light emission of the light sources. Consequently, in typical LED-based light engines, e.g. having 50-150 LEDs, the increase in light efficiency obtained in respect of each LED by far outweighs the reduced space available for placement of LEDs on the support plate due to the central aperture. For example, in one embodiment, the support plate may be a circular plate having a diameter of 15 cm with a central, circular hole of 4 cm. Hence, the central aperture takes up only approximately 6.5 % of the mounting area that would otherwise be available in the absence of the central hole. This corresponds to e.g. 102 LEDs mountable on the annular support plate as compared to 109 LEDs that would be mountable on the circular disk without central aperture. Even considering about 5-10 % reflection losses at the reflector, it is expected that the light efficiency of embodiments of the present light engine provide an about 20% increase of the light efficiency compared to prior art lens-based light engines.

[0036] Hence, generally, the collimators may direct respective parallel, collimated light beams towards a parabolic reflector such that the light beams are parallel with the optical axis of the parabolic reflector and the reflector may focus the incoming parallel beams into a beam spot on the optical axis. However, in alternative embodiments, the concave reflector may have a different geometric shape and the beams from the collimators may not necessarily be all parallel with each other or not parallel with the optical axis. The collimated beams may further be partially collimated, i.e. slightly divergent or convergent.

[0037] In the example of FIG. 1, the diffuser plate 106 is arranged in the same plane as the output surfaces of the collimators. However, in other embodiments the diffuser may be arranged in the plane of the light sources 101 or in the plane of the support plate 113. Similarly, the reflector 104 may be configured to focus the converging beam 105 at a different distance from the reflector, e.g. in the plane of the light sources or the plane of the support plate 113. Moreover, in other embodiments of a light engine, the diffuser plate may be omitted or replaced by another optical element such as a microlens array or small aperture.

[0038] FIGS. 3 and 4 show more detailed views of examples of a light source 101 with a collimating lens 102. In both examples the collimator is a TIR lens having a light-receiving input surface that faces the light source 101 and a light-emitting output surface that faces away from the light source 101 and towards the reflector 104. The input surface has a central portion and an annular portion 318 surrounding the central portion. The central portion 309 is formed as a bottom of a recess while the annular portion 318 is formed by the side walls of the recess. The light source 101 is positioned at the centre of (i.e. axially aligned with) the recess and such that the light predominantly emitted normal to the light-emitting surface of the light source impinges on the central portion of the input surface, while light predominantly emitted along the light-emitting face of the light source impinges on the annular portion 318 of the input surface. For example, the light source may be positioned flush with a rim of the recess or partly extending into the recess. The central portion 309 is convex so as to collimate the received light from the light source 101. The annular portion 318 is also convex so as to cause a collimation of the incoming light. The light entering the collimator lens 102 through the annular portion 318 impinges on a circumferential lateral surface 310 of the lens. The lateral surface defines an angle relative to the optical axis such that the light is redirected from the lateral surface by total internal reflection as collimated light 103 through the output surface of the lens 102. The lateral surface may also be curved so as to contribute to the collimation. Surface 318 may have infinite radius of curvature. Hence, light emitted axially along or at small angles (e.g. less than 45° such as less than 30°) relative to the optical axis are collimated by the central portions, while light emitted laterally at larger angles (e.g. more than 30° such as more than 45°) relative to the optical axis are received by the annular portion and redirected by the lateral surface.

[0039] In the example of FIG. 3 the output surface 311 is planar, while the output surface of the lens shown in FIG. 4 has a central portion 412 and an annular portion surrounding the central portion. The central portion 412 is convex and contributes to the collimating effect of the central portion 309 of the input surface of the lens. The annular portion 411 surrounds the central portion and may be planar or convex so as to contribute to the collimating effect of the annular portion 309 of the input sur-

face and of the lateral surface 310. The central portion 412 usually has a smaller radius of curvature than the annular portion 411.

[0040] FIG. 5 shows an example of an illumination device. The illumination device comprises a housing 517, a light engine 100 (illustrated by a dashed dotted line) as described in connection with FIG. 1, and a lens 515 that receives the light 108 output by the light engine 100 and directs the light 516 towards an area to be illuminated. The light engine 100 and the lens 515 are arranged within the housing 517. The lens 515 may be a collimating or focussing lens; it may be movably arranged so as to vary the characteristics of the light 516 output by the illumination device. It will be appreciated that embodiments of an illumination device may comprise other optical elements in addition or alternative to the lens 515.

[0041] FIG. 6 illustrates a cross-sectional view of another example of a light engine. The light engine 100 of FIG. 6 is similar to the light engine described with reference to FIG. 1 in that it comprises a plurality of light sources 101, a plurality of collimators 102, a concave reflector 104 and a diffuser plate 106, all as described in connection with FIG. 1. The light engine of FIG. 6 differs from the light engine of FIG. 1 in that the concave reflector 104 comprises a central hole 621 surrounded by an annular reflective surface 620. The light from the light sources 101 is directed predominantly towards the annular reflective surface 620 and not (or at least not significantly) towards the central opening 621. The light engine further comprises additional light sources 622, e.g. LEDs, arranged in or behind the opening 621 and facing the central aperture defined by the support plate 113. The light engine further comprises additional collimating TIR lenses 623, similar to lenses 102, (or other suitable collimators) adapted to collimate the light from the additional light sources 622 towards the central aperture of support plate 113. The light engine further comprises a focusing lens 619 operable to receive the collimated light from the collimating TIR lenses and provide a converging beam that converges towards the same beam spot 107 as the converging reflected beam from the reflector 104. Consequently, in the embodiment of FIG. 6, the total light-emitting area of the light engine is increased, thus allowing a larger number of light sources to be provided without increasing the overall dimensions of the light engine.

[0042] It will be appreciated that the collimating TIR lenses 623 and the focusing lens 619 may be combined in a single optical element, e.g. as shown in FIG. 7. In particular, FIG. 7 illustrates a cross-sectional view of another example of a light engine. The light engine 100 of FIG. 7 is similar to the light engine described with reference to FIG. 6, but where the light from the additional light sources 622 is directed and converged towards the beam spot 107 by a single TIR lens structure 723. The lens structure 723 has a light-receiving input face having multiple input portions, one for each of the additional light sources 622. Each input portion is similar to the light-receiving input face of lenses 102, while the light-emitting

output face of lens structure 723 is formed as a common Fresnel lens.

[0043] FIG. 8 illustrates a cross-sectional view of yet another example of a light engine. The light engine 100 of FIG. 8 is similar to the light engine described with reference to FIG. 7, but where the single TIR lens structure is replaced by multiple TIR lenses 823, one for each light source 622. Each lens 823 has a light-receiving input face similar to the light-receiving input face of lenses 102, while the light-emitting output faces of lenses 823 together form a Fresnel lens.

[0044] FIG. 9 illustrates a cross-sectional view of yet another example of a light engine. The light engine 100 of FIG. 9 is similar to the light engine described with reference to FIG. 7, but further comprising yet another set of one or more additional light sources 926 and corresponding one or more optical elements 925. Moreover, the reflector 104 is formed as an interference filter configured to transmit light having wavelengths above a threshold wavelength, e.g. 600 nm, and to reflect light below the threshold wavelength. The interference filter has a central opening 621, thus defining an annular, partially reflective and partially transmissive surface. The additional light source(s) 926 and optical element(s) 925 are placed behind (as seen from the central aperture of support plate 113) the annular concave reflector 104. Moreover, the light sources 101 are operable to at least predominantly emit light in a wavelength range below the threshold wavelength of the interference filter (such that the light from the light sources 101 is reflected by the interference filter) while the further light sources 926 behind the reflector are operable to at least predominantly emit light above the threshold wavelength (such that the light from the additional light sources 926 is transmitted by the interference filter 104). For example, the light sources may be green and/or blue LEDs, while the further light sources 926 may be red LEDs. Optionally the light engine may comprise light sources 622 radially arranged within the central opening (e.g. axially in front of the opening, behind the opening or within the opening), e.g. as described in connection with FIG. 7. These central light sources 622 may emit white light or light having another desired spectral distribution.

[0045] Although some embodiments have been described and shown in detail, the invention is not restricted to them, but may also be embodied in other ways within the scope of the subject matter defined in the following claims. In particular, it is to be understood that other embodiments may be utilised and structural and functional modifications may be made without departing from the scope of the present invention.

[0046] In device claims enumerating several means, several of these means can be embodied by one and the same item of hardware. The mere fact that certain measures are recited in mutually different dependent claims or described in different embodiments does not indicate that a combination of these measures cannot be used to advantage.

[0047] It should be emphasized that the term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

Claims

1. A light engine for an illumination device, the light engine defining an output gate and being configured to output light from said output gate; wherein the light engine comprises:
 - one or more light sources defining a light-emitting area;
 - a concave reflector configured to receive light from the light-emitting area and to direct light from respective portions of the light-emitting area to form a converging beam that converges towards a beam spot at the output gate.
2. A light engine according to claim 1, comprising a plurality of light sources distributed across the light-emitting area.
3. A light engine according to any one of the preceding claims, wherein the light-emitting area is an annular area defining a central aperture; and wherein the concave reflector is arranged to combine the light from the light sources to direct the converging beam through the aperture.
4. A light engine according to claim 3; wherein the concave reflector comprises an annular portion and a central portion surrounded by the annular portion, wherein the annular portion is formed by or comprises a reflective surface operable to reflect the light from the one or more light sources; wherein the light engine is operable to direct light from the one or more light sources at least predominantly towards the annular portion of the concave reflector; and wherein the light engine comprises one or more additional light sources aligned with the central portion of the concave reflector and operable to direct light towards the central aperture.
5. A light engine according to any one of the preceding claims, comprising at least one collimator configured to direct light from at least one of the one or more light sources as at least partially collimated light towards the reflector and wherein the reflector is arranged to reflect the collimated light as a converging beam towards said beam spot at said output gate.
6. A light engine according to claim 5, comprising a plurality of light sources and a plurality of collimators

each adapted to receive light from one of the light sources and to direct a collimated beam towards the reflector.

7. A light engine according to claim 5 or 6 wherein each collimator comprises a light-receiving input surface, a light-emitting output surface and a lateral surface; wherein the input surface has a central portion and an annular portion; wherein the central portion is configured to collimate received light and to direct the collimated light towards the output surface and wherein the annular portion is operable to direct received light towards the lateral surface for total internal reflection of the light towards the output surface. 5
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8. A light engine according to any one of claims 5 through 7, wherein each collimator comprises a light-emitting output surface having a central portion and an annular portion wherein the central and annular portions have respective radii of curvature. 20
9. A light engine according to any one of claims 5 through 7, wherein each collimator comprises a planar light-emitting output surface. 25
10. A light engine according to any one of the preceding claims operable as a localized light source that, during operation, emits light from the output gate. 30
11. A light engine according to any one of the preceding claims, comprising an aperture defining the output gate, and wherein the concave reflector is configured to direct the converging beam to converge in a beam spot in a plane defined by the aperture. 35
12. A light engine according to any one of the preceding claims, wherein the concave reflector is a parabolic reflector. 40
13. A light engine according to any one of the preceding claims, comprising a diffuser arranged in the focus area. 45
14. A light engine according to any one of the preceding claims, comprising multiple light sources emitting light having different, respective spectral distributions, wherein the concave reflector is operable to generate a combined converging beam comprising light from respective ones of the light sources. 50
15. An illumination device for illuminating an area, the illumination device comprising a light engine as defined in any one of the preceding claims and one or more optical device configured to receive light from the output gate of the light engine and to direct the received light towards an area to be illuminated. 55

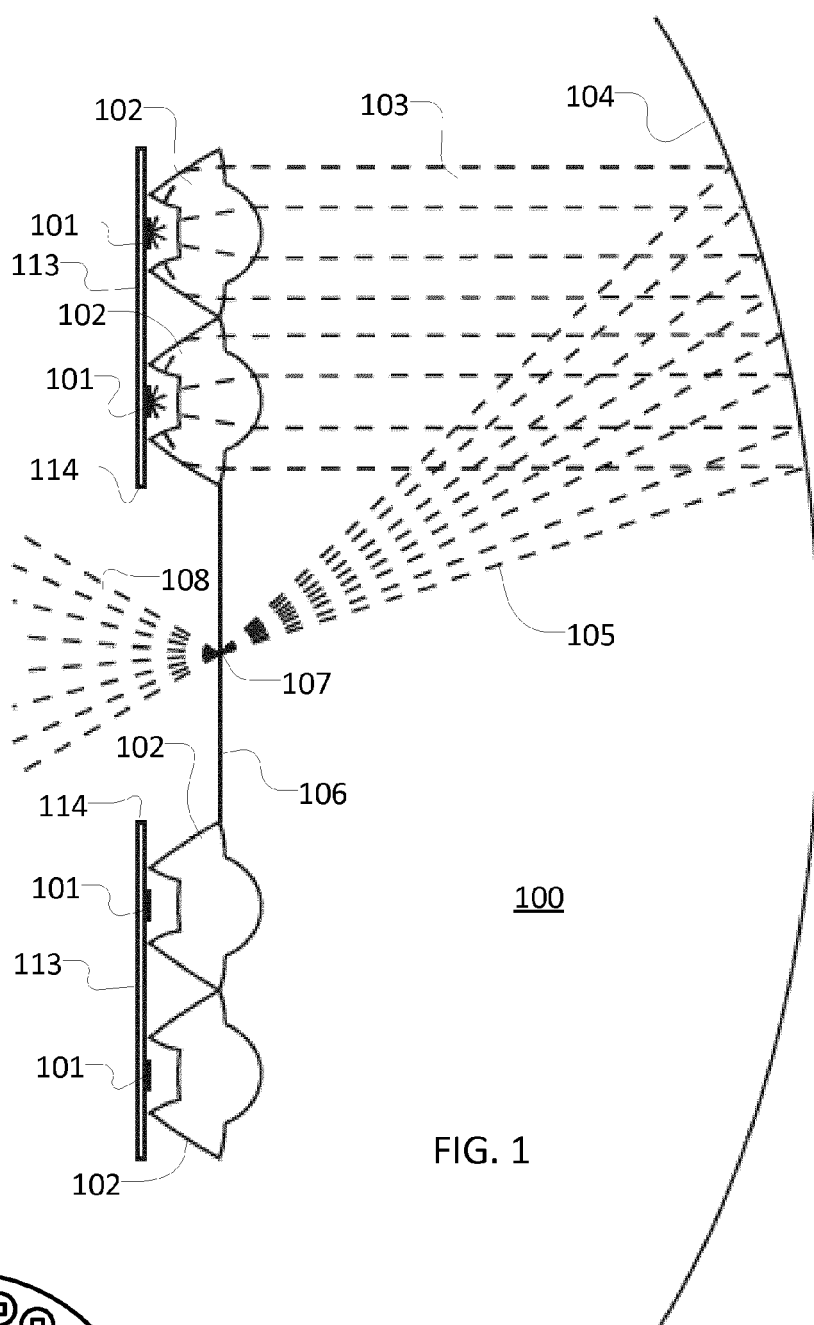


FIG. 1

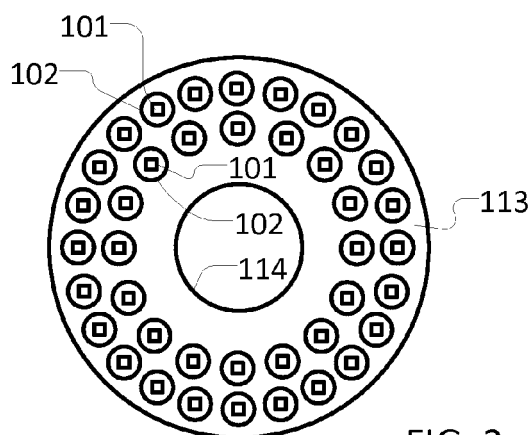
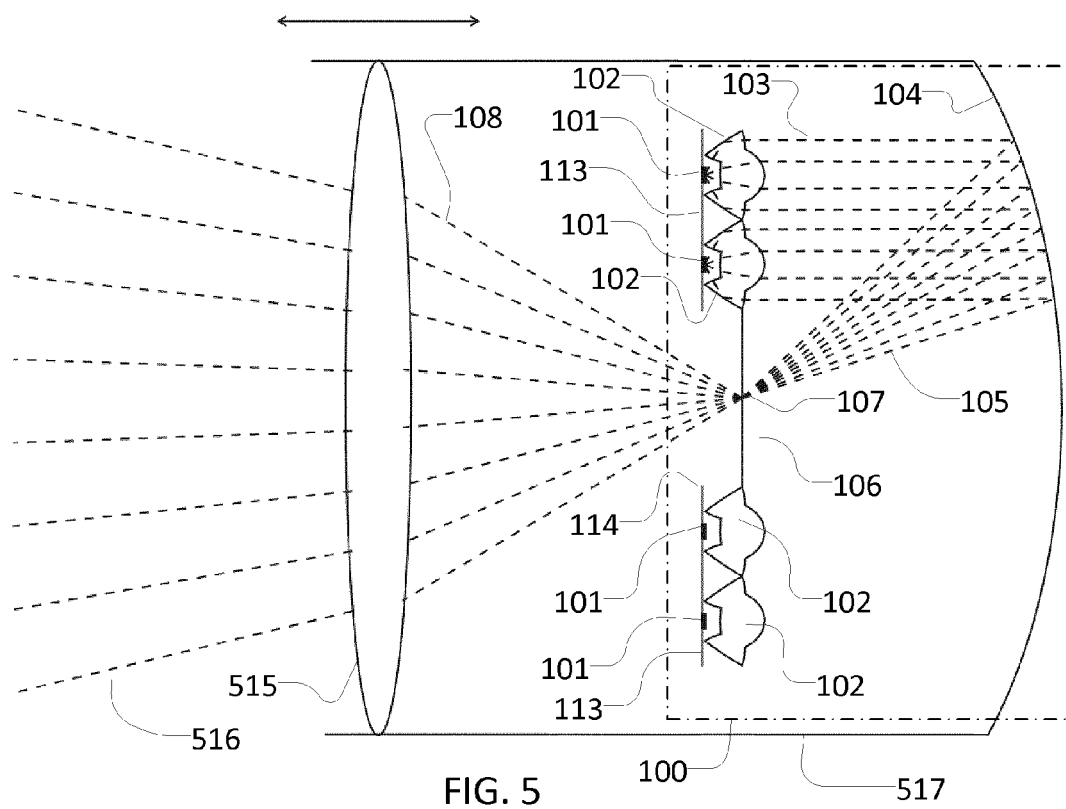
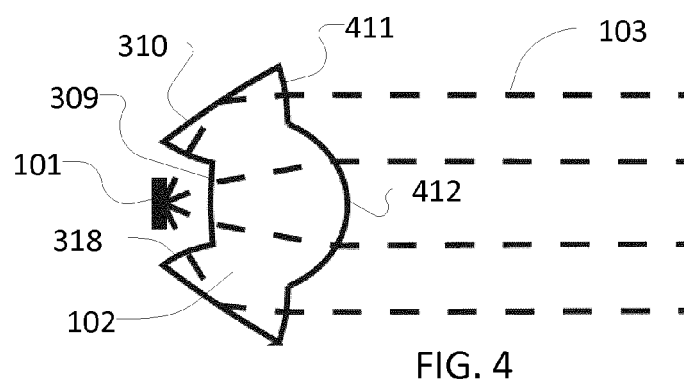
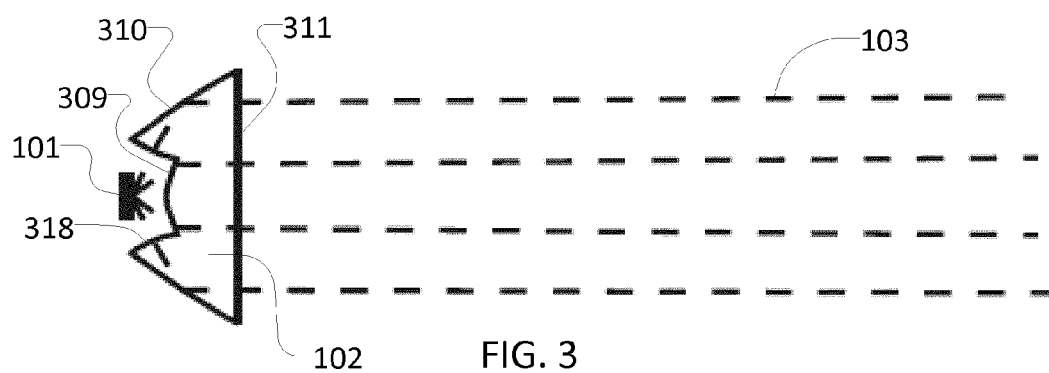


FIG. 2



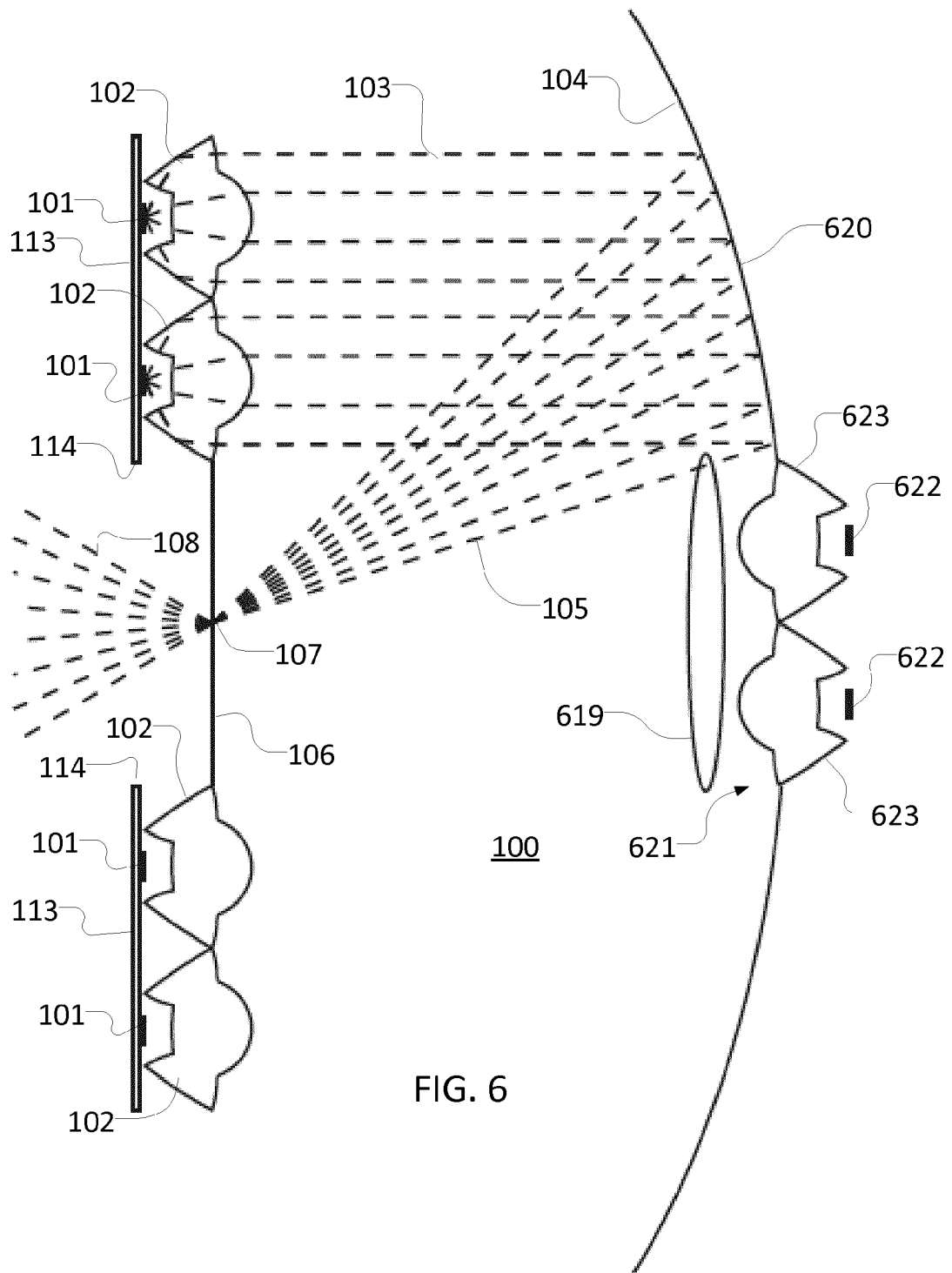
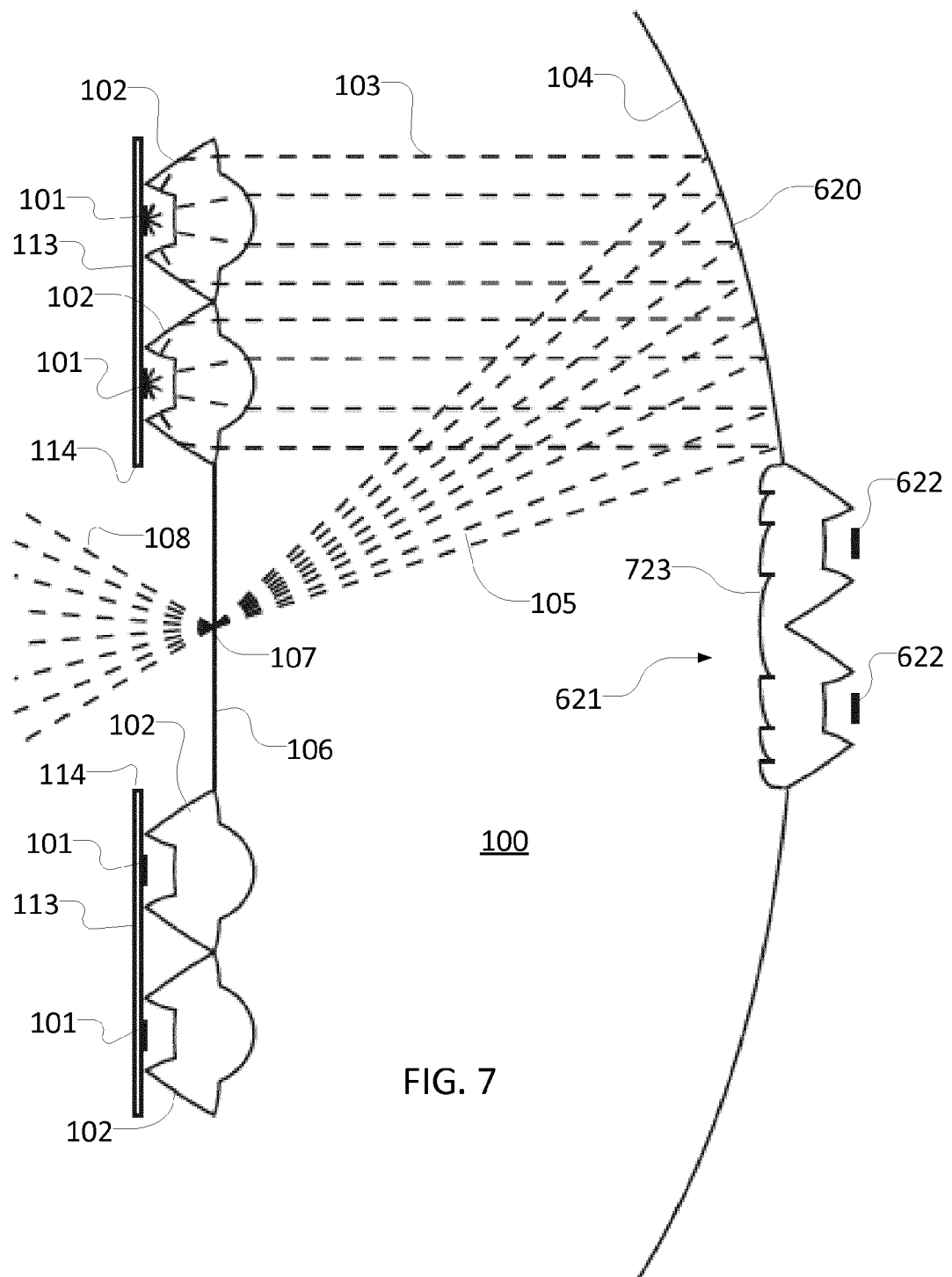
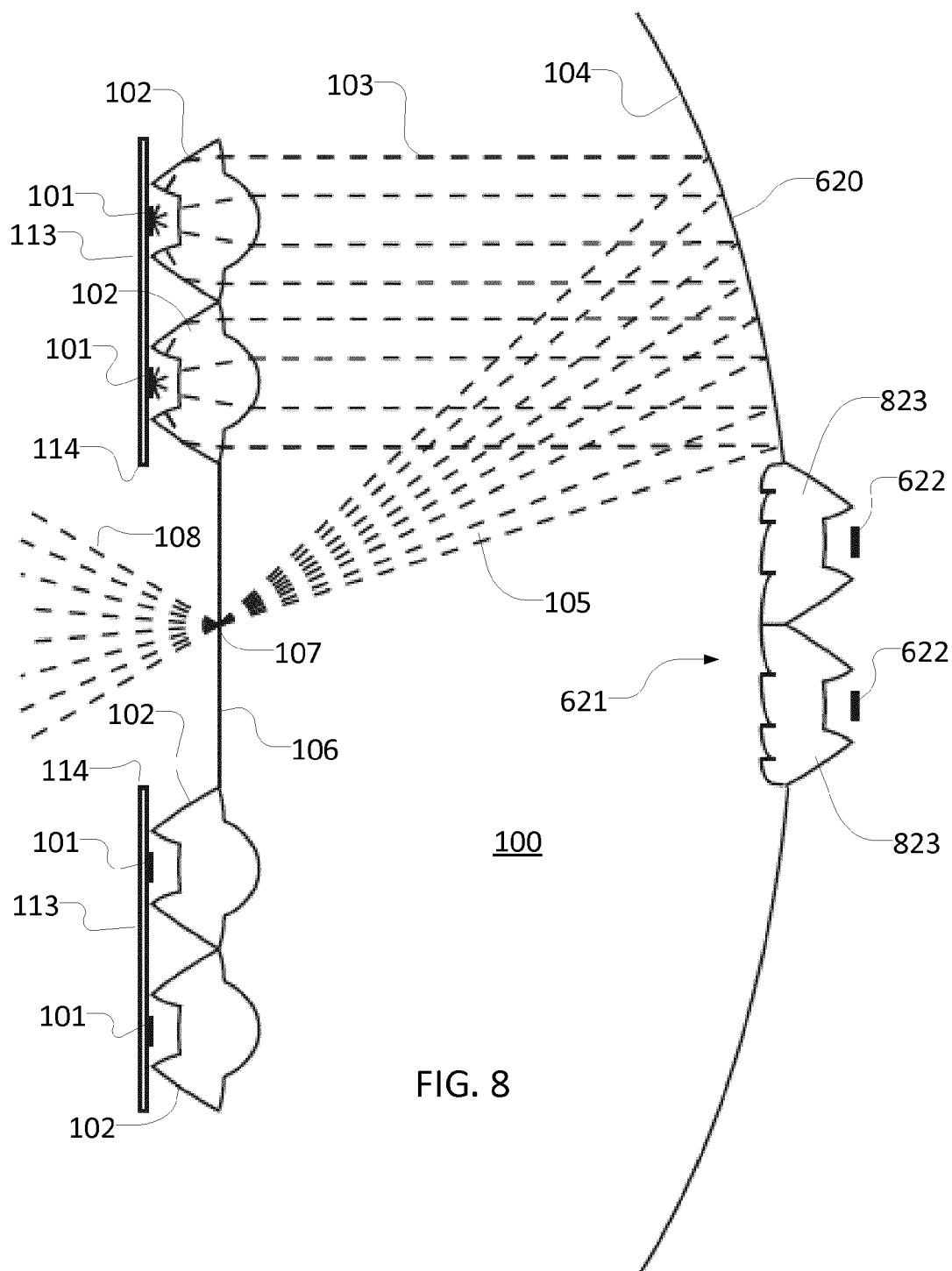


FIG. 6





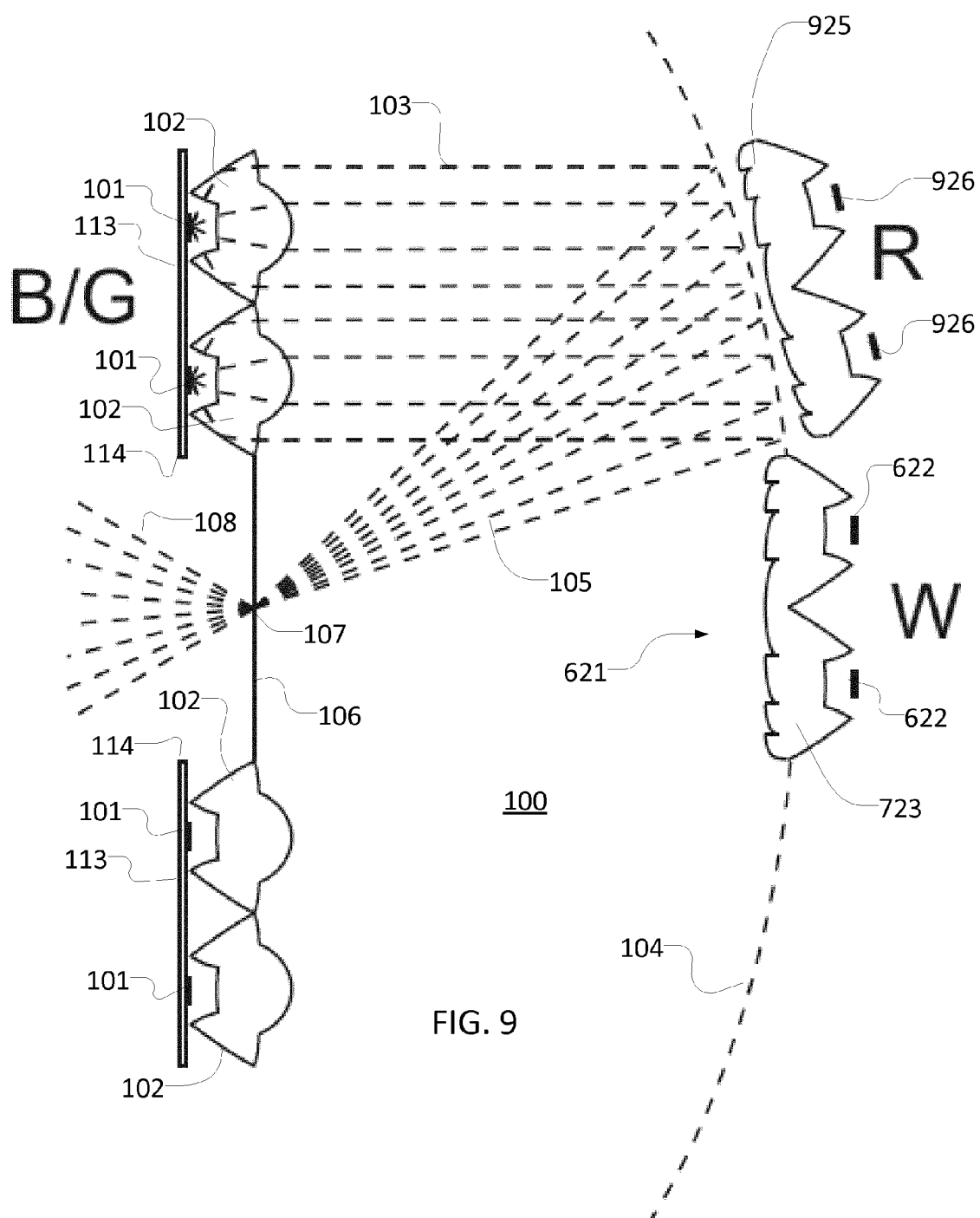


FIG. 9



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Place of search The Hague		Date of completion of the search 19 September 2013	Examiner Thibaut, Arthur
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